CHAPTER 5 (Odd)

1. a. $R_T = 2\ \Omega + 6\ \Omega + 12\ \Omega = \mathbf{20\ \Omega}, I = \frac{E}{R_T} = \frac{60\text{ V}}{20\ \Omega} = \mathbf{3\text{ A}}$

   b. $R_T = 0.2\text{ M}\Omega + 1\text{ M}\Omega + 0.33\text{ M}\Omega + 0.1\text{ M}\Omega = \mathbf{1.63\text{ M}\Omega}$
   $I = \frac{E}{R_T} = \frac{10\text{ V}}{1.63\text{ M}\Omega} = \mathbf{6.135\ \mu A}$

   c. $R_T = 15\ \Omega + 10\ \Omega + 25\ \Omega + 25\ \Omega + 10\ \Omega + 25\ \Omega = \mathbf{110\ \Omega}$
   $I = \frac{E}{R_T} = \frac{35\text{ V}}{110\ \Omega} = \mathbf{318.2\text{ mA}}$

   d. $R_T = 1.2\text{ k}\Omega + 4.5\text{ k}\Omega + 1.3\text{ k}\Omega + 3\text{ k}\Omega = \mathbf{10\text{ k}\Omega}$
   $I = \frac{E}{R_T} = \frac{120\text{ V}}{10\text{ k}\Omega} = \mathbf{12\text{ mA}}$

3. a. $R_T = 60\ \Omega + 1200\ \Omega + 2740\ \Omega = 4\text{ k}\Omega$
   $E = IR_T = (4\text{ mA})(4\text{ k}\Omega) = \mathbf{16\text{ V}}$

   b. $R_T = 1.2\ \Omega + 8.2\ \Omega + 4.7\ \Omega + 2.7\ \Omega = \mathbf{16.8\ \Omega}$
   $E = IR_T = (250\text{ mA})(16.8\ \Omega) = \mathbf{4.2\text{ V}}$

5. a. $R_T = 4.7\ \Omega + 5.6\ \Omega = 10.3\ \Omega$
   $I = \frac{16\text{ V} - 8\text{ V} - 4\text{ V}}{10.3\ \Omega} = \frac{4\text{ V}}{10.3\ \Omega} = \mathbf{0.388\text{ A}}$ (clockwise)

   b. $R_T = 4.7\ \Omega + 1.2\ \Omega + 5.6\ \Omega = 11.5\ \Omega$
   $I = \frac{18\text{ V} + 10\text{ V} - 4\text{ V}}{11.5\ \Omega} = \mathbf{2.087\text{ A}}$ (counterclockwise)

7. a. $+10\text{ V} - 2\text{ V} - 3\text{ V} - V_{\underset{+-}{ab}} = 0$
   $V_{\underset{+-}{ab}} = 10\text{ V} - 5\text{ V} = \mathbf{5\text{ V}}$

   b. $60\text{ V} + 20\text{ V} - V_{\underset{+-}{ab}} - 10\text{ V} = 0$
   $V_{\underset{+-}{ab}} = 80\text{ V} - 10\text{ V} = \mathbf{70\text{ V}}$

9. $I = \frac{27\text{ V} - 9\text{ V} - 5\text{ V}}{2.2\text{ k}\Omega + 1.2\text{ k}\Omega + 0.56\text{ k}\Omega} = \frac{13\text{ V}}{3.96\text{ k}\Omega} = \mathbf{3.28\text{ mA}}$
   $V_1 = IR = (3.28\text{ mA})(2.2\text{ k}\Omega) = \mathbf{7.22\text{ V}}$

11. a. $R_T = 22\ \Omega + 10\ \Omega + 5.6\ \Omega + 33\ \Omega = \mathbf{70.6\ \Omega}$
    $I = \frac{E}{R_T} = \frac{6\text{ V}}{70.6\ \Omega} = 0.085\text{ A} = \mathbf{85\text{ mA}}$ (CCW)
    $V_1 = IR = (85\text{ mA})(33\ \Omega) = \mathbf{2.805\text{ V}}$
    $V_2 = IR = (85\text{ mA})(5.6\ \Omega) = \mathbf{0.476\text{ V}}$
    $V_3 = IR = (85\text{ mA})(10\ \Omega) = \mathbf{0.850\text{ V}}$
    $V_4 = IR = (85\text{ mA})(22\ \Omega) = \mathbf{1.870\text{ V}}$

b. $E = V_1 + V_2 + V_3 + V_4$

$6 \text{ V} = 2.805 \text{ V} + 0.476 \text{ V} + 0.850 \text{ V} + 1.870 \text{ V}$

$6 \text{ V} \stackrel{\checkmark}{=} 6 \text{ V}$

c. 33 Ω: $P = I^2R = (85 \text{ mA})^2\, 33\ \Omega = \mathbf{238.4\ mW}$

5.6 Ω: $P = I^2R = (85 \text{ mA})^2\, 5.6\ \Omega = \mathbf{40.5\ mW}$

10 Ω: $P = I^2R = (85 \text{ mA})^2\, 10\ \Omega = \mathbf{72.3\ mW}$

22 Ω: $P = I^2R = (85 \text{ mA})^2\, 22\ \Omega = \mathbf{159\ mW}$

$P_{del} = EI = (6 \text{ V})(85 \text{ mA}) = 510 \text{ mW}$

$P_{del} = 238.4 \text{ mW} + 40.5 \text{ mW} + 72.3 \text{ mW} + 159 \text{ mW}$

$510 \text{ mW} \stackrel{\checkmark}{=} 510 \text{ mW}$

d. All $\frac{1}{2}$ W.

13. a. $R_T = NR_1 = 8\left[28\frac{1}{8}\ \Omega\right] = \mathbf{225\ \Omega}$

$I = \dfrac{E}{R_T} = \dfrac{120 \text{ V}}{225\ \Omega} = \mathbf{0.533\ A} = \dfrac{8}{15} \text{ A}$

b. $P = I^2R = \left[\dfrac{8}{15} \text{ A}\right]^2\left[28\frac{1}{8}\ \Omega\right] = \left[\dfrac{64}{\cancel{225}}\right]\left[\dfrac{\cancel{225}}{8}\right] = \mathbf{8\ W}$

c. $V = IR = \left[\dfrac{\cancel{8}}{15} \text{ A}\right]\left[\dfrac{225}{\cancel{8}}\ \Omega\right] = \mathbf{15\ V}$

d. All go out!

15. a. $V_{\underset{+-}{ab}} = \dfrac{50\ \Omega(100 \text{ V})}{50\ \Omega + 25\ \Omega} = \mathbf{66.67\ V}$

b. $V_{\underset{+-}{ab}} = \dfrac{-4\ \Omega(80 \text{ V})}{4\ \Omega + 6\ \Omega + 10\ \Omega + 20\ \Omega} = \dfrac{-320 \text{ V}}{40} = \mathbf{-8\ V}$

c. $V_{\underset{+-}{ab}} = \dfrac{(2 \text{ k}\Omega + 3 \text{ k}\Omega)(40 \text{ V})}{(4 \text{ k}\Omega + 1 \text{ k}\Omega + 2 \text{ k}\Omega + 3 \text{ k}\Omega)} = \dfrac{5(40 \text{ V})}{10} = \mathbf{20\ V}$

d. $V_{\underset{+-}{ab}} = \dfrac{(1.5\ \Omega + 0.6\ \Omega + 0.9\ \Omega)(0.36 \text{ V})}{2.5\ \Omega + 1.5\ \Omega + 0.6\ \Omega + 0.9\ \Omega + 0.5\ \Omega}$

$= \dfrac{(3\ \Omega)(0.36 \text{ V})}{6\ \Omega} = \mathbf{0.18\ V}$

17. a. 12 V

b. $V_3 = E - V_1 - V_2 = 40 \text{ V} - 4 \text{ V} - 12 \text{ V} = \mathbf{24\ V}$

c. $\dfrac{V_3}{V_1} = \dfrac{R_3}{R_1}$ and $R_3 = \dfrac{V_3}{V_1}R_1 = \dfrac{24 \text{ V}}{4 \text{ V}} \cdot 10\ \Omega = (6)(10\ \Omega) = \mathbf{60\ \Omega}$

d. $I = \frac{E}{R_T} = \frac{40 \text{ V}}{10\ \Omega + 30\ \Omega + 60\ \Omega} = \frac{40 \text{ V}}{100\ \Omega} = \mathbf{0.4\ A}$

e. $R_3 = \frac{V_3}{I} = \frac{24 \text{ V}}{0.4 \text{ A}} = \mathbf{60\ \Omega}$ (checks)

19. a. $R_{\text{bulb}} = \frac{V}{I} = \frac{8 \text{ V}}{50 \text{ mA}} = 160\ \Omega$

$$V_{R_s} = 12 \text{ V} - 8 \text{ V} = 4 \text{ V} = \frac{R_s\, 12 \text{ V}}{R_s + 160\ \Omega}$$
$$(R_s + 160\ \Omega)4 \text{ V} = R_s\, 12 \text{ V}$$
$$4R_s + 640\ \Omega = 12R_s$$
$$8R_s = 640\ \Omega$$
$$R_s = \frac{640\ \Omega}{8} = \mathbf{80\ \Omega}$$

b. $P = I^2R = (50 \text{ mA})^2\, 80\ \Omega = 0.2 \text{ W} < \mathbf{\frac{1}{4}}\text{ W}$

21. $R_T = \frac{V}{I} = \frac{72 \text{ V}}{4 \text{ mA}} = 18 \text{ k}\Omega$
$V_{R_1} = 0.2V_{R_2}$
$IR_1 = 0.2IR_2$
and $R_1 = 0.2R_2$
but $R_T = R_1 + R_2 = 18 \text{ k}\Omega$
and $0.2R_2 + R_2 = 18 \text{ k}\Omega$
or $R_2 = \frac{18 \text{ k}\Omega}{1.2} = \mathbf{15\ k\Omega}$
with $R_1 = 0.2R_2 = 0.2(15 \text{ k}\Omega) = \mathbf{3\ k\Omega}$

23. a. $E = V_{R_1} + V_{R_2} + V_{R_3}$
$= V_{R_1} + 3V_{R_1} + 4V_{R_2} = V_{R_1} + 3V_{R_1} + 4(3V_{R_1}) = V_{R_1} + 3V_{R_1} + 12V_{R_1}$
with $E = 16V_{R_1}$

and $V_{R_1} = \frac{E}{16} = \frac{64 \text{ V}}{16} = 4 \text{ V}$
$V_{R_2} = 3V_{R_1} = 3(4 \text{ V}) = 12 \text{ V}$
$V_{R_3} = 4V_{R_2} = 4(12 \text{ V}) = 48 \text{ V}$

$R_1 = \frac{V_{R_1}}{I} = \frac{4 \text{ V}}{10 \text{ mA}} = \mathbf{0.4\ k\Omega}$, $R_2 = \frac{V_{R_2}}{I} = \frac{12 \text{ V}}{10 \text{ mA}} = \mathbf{1.2\ k\Omega}$

$R_3 = \frac{V_{R_3}}{I} = \frac{48 \text{ V}}{10 \text{ mA}} = \mathbf{4.8\ k\Omega}$

b. Voltage levels remain the same
$R_1 = \mathbf{0.4\ M\Omega}$, $R_2 = \mathbf{1.2\ M\Omega}$, $R_3 = \mathbf{4.8\ M\Omega}$

25. a. $I(\text{CW}) = \frac{120 \text{ V} - 60 \text{ V}}{6\ \Omega + 3\ \Omega} = \frac{60 \text{ V}}{9\ \Omega} = \mathbf{6.667\ A}$
$V = IR = (6.667 \text{ A})(3\ \Omega) = \mathbf{20\ V}$

b. $I(\text{CW}) = \dfrac{70\text{ V} - 10\text{ V}}{10\ \Omega + 20\ \Omega + 30\ \Omega} = \dfrac{60\text{ V}}{60\ \Omega} = \mathbf{1\ A}$

$V = IR = (1\text{ A})(10\ \Omega) = \mathbf{10\ V}$

27. $I = \dfrac{47\text{ V} - 20\text{ V}}{2\text{ k}\Omega + 3\text{ k}\Omega + 4\text{ k}\Omega} = \dfrac{27\text{ V}}{9\text{ k}\Omega} = 3\text{ mA (CCW)}$

$V_{2k\Omega} = 6\text{ V},\ V_{3k\Omega} = 9\text{ V},\ V_{4k\Omega} = 12\text{ V}$

a. $V_a = \mathbf{20\ V},\ V_b = 20\text{ V} + 6\text{ V} = \mathbf{26\ V},\ V_c = 20\text{ V} + 6\text{ V} + 9\text{ V} = \mathbf{35\ V}$

$V_d = \mathbf{-12\ V},\ V_e = \mathbf{0\ V}$

b. $V_{ab} = \mathbf{-6\ V},\ V_{dc} = \mathbf{-47\ V},\ V_{cb} = \mathbf{9\ V}$

c. $V_{ac} = \mathbf{-15\ V},\ V_{db} = -47\text{ V} + 9\text{ V} = \mathbf{-38\ V}$

29. $V_0 = \mathbf{0\ V}$

$V_4 = -12\text{ V} + 2\text{ V} = 0,\ V_4 = \mathbf{+10\ V}$

$V_7 = \mathbf{4\ V}$

$V_{10} = \mathbf{20\ V}$

$V_{23} = \mathbf{+6\ V}$

$V_{30} = \mathbf{-8\ V}$

$V_{67} = \mathbf{0\ V}$

$V_{56} = \mathbf{-6\ V}$

$I = \dfrac{V_4}{4\ \Omega} = \dfrac{V_{23}}{4\ \Omega} = \dfrac{6\text{ V}}{4\ \Omega} = 1.5\text{ A}\uparrow$

31. $R_{\text{int}} = \dfrac{V_{NL}}{I} - R_L = \dfrac{60\text{ V}}{2\text{ A}} - 28\ \Omega = \mathbf{2\ \Omega}$

33. $R_{\text{int}} = \dfrac{V_{NL}}{I} - R_L = \dfrac{6\text{ V}}{10\text{ mA}} - 500\ \Omega = \mathbf{100\ \Omega}$

35. $VR\% = \dfrac{R_{\text{int}}}{R_L} \times 100\% = \dfrac{0.05\ \Omega}{3.3\ \Omega} \times 100\%$

$= \mathbf{1.52\%}$

CHAPTER 5 (Even)

2. a. $R_T = 30\ \Omega = 10\ \Omega + 12\ \Omega + R$

$R = \mathbf{8\ \Omega}$

$I = \frac{E}{R_T} = \frac{30\ \text{V}}{30\ \Omega} = \mathbf{1\ A}$

b. $R_T = 60\ \text{k}\Omega = 12.6\ \text{k}\Omega + R + 0.4\ \text{k}\Omega + 45\ \text{k}\Omega$

$R = \mathbf{2\ k\Omega}$

c. $R_T = 220\ \Omega = 50\ \Omega + R_1 + 60\ \Omega + R_1 + 10\ \Omega$

$220\ \Omega = 120\ \Omega + 2R_1$

$R_1 = \mathbf{50\ \Omega} = R_2$

$I = \frac{E}{R_T} = \frac{120\ \text{V}}{220\ \Omega} = \mathbf{0.5455\ A}$

d. $R_T = 1600\ \text{k}\Omega = 200\ \text{k}\Omega + 56\ \text{k}\Omega + 100\ \text{k}\Omega + R$

$R = 1{,}224\ \text{k}\Omega = 1.244\ \text{M}\Omega$

$I = \frac{E}{R_T} = \frac{50\ \text{V}}{1.6\ \text{M}\Omega} = \mathbf{31.25\ \mu A}$

4. a. $I = \frac{12\ \text{V}}{2\ \Omega} = \mathbf{6\ A}$

$R_T = 16\ \Omega = 5\ \Omega + 2\ \Omega + R$

$R = \mathbf{9\ \Omega}$

$V_{5\Omega} = (I)(5\ \Omega) = (6\ \text{A})(5\ \Omega) = \mathbf{30\ V}$

$V_{9\Omega} = (I)(9\ \Omega) = (6\ \text{A})(9\ \Omega) = \mathbf{54\ V}$

$E = 30\ \text{V} + 12\ \text{V} + 54\ \text{V} = \mathbf{96\ V}$

b. $P = I^2R \Rightarrow I = \sqrt{\frac{P}{R}} = \sqrt{\frac{79.2\ \text{mW}}{2.2\ \text{k}\Omega}} = \sqrt{36 \times 10^{-6}}$

$= 6 \times 10^{-3}\text{A} = \mathbf{6\ mA}$

$R = \frac{V}{I} = \frac{9\ \text{V}}{6\ \text{mA}} = \mathbf{1.5\ k\Omega}$

$V_{3.3\text{k}\Omega} = IR = (6\ \text{mA})(3.3\ \text{k}\Omega) = \mathbf{19.8\ V}$

$V_{2.2\text{k}\Omega} = IR = (6\ \text{mA})(2.2\ \text{k}\Omega) = \mathbf{1.32\ V}$

$E = 1.32\ \text{V} + 9\ \text{V} + 19.8\ \text{V} = \mathbf{30.12\ V}$

6. a. $P = I^2R \Rightarrow R = \frac{P}{I^2} = \frac{100\ \text{mW}}{(5\ \text{mA})^2} = \mathbf{4\ k\Omega}$

$I(\text{CW}) = 5\ \text{mA} = \frac{E + 20\ \text{V}}{5\ \text{k}\Omega + 4\ \text{k}\Omega}$

$E + 20\ \text{V} = 5\ \text{mA}(9\ \text{k}\Omega) = 45\ \text{V}$

$E = 45\ \text{V} - 20\ \text{V} = \mathbf{25\ V}$

b. $I = \dfrac{16\text{ V}}{2\text{ k}\Omega} = \mathbf{8\text{ mA}},\ R = \dfrac{12\text{ V}}{I} = \dfrac{12\text{ V}}{8\text{ mA}} = \mathbf{1.5\text{ k}\Omega}$

$I(\text{CCW}) = 8\text{ mA} = \dfrac{E - 8\text{ V} - 6\text{ V}}{2\text{ k}\Omega + 1.5\text{ k}\Omega}$

$E - 14\text{ V} = 8\text{ mA}(3.5\text{ k}\Omega) = 28\text{ V}$

$E = 28\text{ V} + 14\text{ V} = \mathbf{42\text{ V}}$

8. a. $V_2 = \mathbf{+10\text{ V}}$

KVL: $+10\text{ V} - 6\text{ V} - V_1 = 0$

$V_1 = \mathbf{4\text{ V}}$

b. KVL: $24\text{ V} - 10\text{ V} - V_1 = 0$

$V_1 = \mathbf{14\text{ V}}$

$10\text{ V} - V_2 + 6\text{ V} = 0$

$V_2 = 10\text{ V} + 6\text{ V} = \mathbf{16\text{ V}}$

10. a. $R_T = 3\text{ k}\Omega + 1\text{ k}\Omega + 2\text{ k}\Omega = \mathbf{6\text{ k}\Omega}$

$I = \dfrac{E}{R_T} = \dfrac{120\text{ V}}{6\text{ k}\Omega} = \mathbf{20\text{ mA}}$

$V_1 = IR_1 = (20\text{ mA})(3\text{ k}\Omega) = \mathbf{60\text{ V}}$

$V_2 = IR_2 = (20\text{ mA})(1\text{ k}\Omega) = \mathbf{20\text{ V}}$

$V_3 = IR_3 = (20\text{ mA})(2\text{ k}\Omega) = \mathbf{40\text{ V}}$

b. $E = V_1 + V_2 + V_3$

$120\text{ V} \overset{\checkmark}{=} 60\text{ V} + 20\text{ V} + 40\text{ V} = 120\text{ V}$

c. $P_1 = V_1I = (60\text{ V})(20 \times 10^{-3}\text{ A}) = \mathbf{1.2\text{ W}}$

$P_2 = V_2I = (20\text{ V})(20\text{ mA}) = \mathbf{0.4\text{ W}}$

$P_3 = V_3I = (40\text{ V})(20\text{ mA}) = \mathbf{0.8\text{ W}}$

$P_{del} = EI = (120\text{ V})(20\text{ mA}) = \mathbf{2.4\text{ W}}$

$P_{del} = P_1 + P_2 + P_3$

$2.4\text{ W} \overset{\checkmark}{=} 1.2\text{ W} + 0.4\text{ W} + 0.8\text{ W} = 2.4\text{ W}$

d. $R_1 \Rightarrow 2\text{W},\ R_2 \Rightarrow \dfrac{1}{2}\text{ W},\ R_3 \Rightarrow 1\text{ W}$

12. a. $V = 120\text{ V} - 80\text{ V} = \mathbf{40\text{ V}}$

$I = \dfrac{40\text{ V}}{20\ \Omega} = \mathbf{2A}$

$R = \dfrac{V}{I} = \dfrac{80\text{ V}}{2\text{ A}} = \mathbf{40\ \Omega}$

b. $I = \dfrac{8\text{ V}}{2.2\ \Omega} = \mathbf{3.636\text{ A}}$

$V_1 = I(4.7\ \Omega) = \mathbf{17.09\text{ V}}$

$V_2 = I(6.8\ \Omega) = \mathbf{24.73\text{ V}}$

c. $P = I^2R \Rightarrow R = P/I^2 = 21\text{ W}/(1\text{ A})^2 = \mathbf{21\ \Omega}$

$V_1 = IR = (1\text{ A})(2\ \Omega) = \mathbf{2\text{ V}}$

$V_2 = IR = (1\text{ A})(1\ \Omega) = \mathbf{1\text{ V}}$

$V_3 = IR = (1\text{ A})(21\ \Omega) = \mathbf{21\text{ V}}$

$E = V_1 + V_2 + V_3 = 2\text{ V} + 1\text{ V} + 21\text{ V} = \mathbf{24\text{ V}}$

d. $P = I^2R \Rightarrow I = \sqrt{\frac{P}{R}} = \sqrt{\frac{4\text{ W}}{1\ \Omega}} = 2\text{ A}$

$R_1 = \frac{P}{I^2} = \frac{8\text{ W}}{(2\text{ A})^2} = \frac{8}{4} = 2\ \Omega$

$R_T = 16\ \Omega = R_1 + R_2 + 1\ \Omega$

$= 2\ \Omega + R_2 + 1\ \Omega$

$R_2 = \mathbf{13\ \Omega}$

$E = IR_T = (2\text{ A})(16\ \Omega) = \mathbf{32\text{ V}}$

14. $R_1 + R_2 = 6\ \Omega,\ P_{del} = P_1 + P_2$

$24\text{ V} \cdot I = I^2 \cdot 6\ \Omega + 24\text{ W}$

$I^2 - 4I + 4 = 0$

$I = \frac{-(-4) \pm \sqrt{16 - 4(1)(4)}}{2(1)} = 2\text{ A}$

and $R = \frac{P}{I^2} = \frac{24\text{ W}}{(2\text{ A})^2} = \frac{24\text{ W}}{4\text{ A}^2} = \mathbf{6\ \Omega}$

16. a. $V_R = 4\text{ V} = \frac{R(20\text{ V})}{R + 2\text{ k}\Omega + 6\text{ k}\Omega}$

$4R + 32\text{ k}\Omega = 20\text{ R}$

$R = \mathbf{2\text{ k}\Omega}$

b. $V = 140\text{ V} = \frac{(R + 6\ \Omega)(200\text{ V})}{(R + 6\ \Omega) + 3\ \Omega}$

$140R + 9(140) = 200R + 1200$

$R = \mathbf{1\ \Omega}$

18. $I_{R_2} = \frac{8\text{ V}}{8\ \Omega} = 1\text{ A},\ R_1 = \frac{V_{R_1}}{I} = \frac{8\text{ V}}{1\text{ A}} = \mathbf{8\ \Omega},\ R_3 = \frac{V_{R_3}}{I} = \frac{4\text{ V}}{1\text{ A}} = \mathbf{4\ \Omega}$

20. $V_{R_2} = 48\text{ V} - 12\text{ V} = 36\text{ V}$

$R_2 = \frac{V_{R_2}}{I} = \frac{36\text{ V}}{16\text{ mA}} = \mathbf{2.25\text{ k}\Omega}$

$V_{R_3} = 12\text{ V} - 0\text{ V} = 12\text{ V}$

$R_3 = \frac{V_{R_3}}{I} = \frac{12\text{ V}}{16\text{ mA}} = \mathbf{0.75\text{ k}\Omega}$

$V_{R_4} = 20\text{ V}$

$R_4 = \frac{V_{R_4}}{I} = \frac{20\text{ V}}{16\text{ mA}} = \mathbf{1.25\text{ k}\Omega}$

$V_{R_1} = E - V_{R_2} - V_{R_3} - V_{R_4}$

$= 100\text{ V} - 36\text{ V} - 12\text{ V} - 20\text{ V} = 32\text{ V}$

$R_1 = \frac{V_{R_1}}{I} = \frac{32\text{ V}}{16\text{ mA}} = \mathbf{2\text{ k}\Omega}$

22. $V_{R_3} = \frac{R_3(60\text{ V})}{R_3 + 2R_3 + 7R_3} = \frac{R_3(60\text{ V})}{10R_3} = \mathbf{6\text{ V}}$

$V_{R_2} = 7V_{R_3} = 7(6\text{ V}) = \mathbf{42\text{ V}}$

$V_{R_1} = 2V_{R_3} = 2(6\text{ V}) = \mathbf{12\text{ V}}$

24. a. $V_a = +12\text{ V} - 8\text{ V} = \mathbf{4\text{ V}}$
$V_b = \mathbf{-8\text{ V}}$
$V_{ab} = V_a - V_b = 4\text{ V} - (-8\text{ V}) = \mathbf{12\text{ V}}$

b. $V_a = 20\text{ V} - 6\text{ V} = \mathbf{14\text{ V}}$
$V_b = \mathbf{+4\text{ V}}$
$V_{ab} = V_a - V_b = 14\text{ V} - 4\text{ V} = \mathbf{10\text{ V}}$

c. $V_a = +10\text{ V} + 3\text{ V} = \mathbf{13\text{ V}}$
$V_b = \mathbf{-8\text{ V}}$
$V_{ab} = \mathbf{21\text{ V}}$

26. a. $I = \dfrac{16\text{ V} - 8\text{ V}}{10\ \Omega + 20\ \Omega} = \dfrac{8\text{ V}}{30\ \Omega} = 0.267\text{ A (CW)}$
$V_a = 16\text{ V} - I(10\ \Omega) = 16\text{ V} - (0.267\text{ A})(10\ \Omega) = 16\text{ V} - 2.67\text{ V} = \mathbf{13.33\text{ V}}$
$V_1 = IR = (0.267\text{ A})(20\ \Omega) = \mathbf{5.34\text{ V}}$

b. $I = \dfrac{12\text{ V} + 10\text{ V} + 8\text{ V}}{2.2\text{ k}\Omega + 3.3\text{ k}\Omega} = \dfrac{30\text{ V}}{5.5\text{ k}\Omega} = 5.455\text{ mA}$
$V_a = 12\text{ V} - I(2.2\text{ k}\Omega) + 10\text{ V}$
$= 12\text{ V} - (5.455\text{ mA})(2.2\text{ k}\Omega) + 10\text{ V}$
$= 12\text{ V} - 12\text{ V} + 10\text{ V} = \mathbf{10\text{ V}}$
$V_1 = I(2.2\text{ k}\Omega) = (5.455\text{ mA})(2.2\text{ k}\Omega) = \mathbf{12\text{ V}}$

28. $I = \dfrac{44\text{ V} - 20\text{ V}}{2\text{ k}\Omega + 4\text{ k}\Omega + 6\text{ k}\Omega} = \dfrac{24\text{ V}}{12\text{ k}\Omega} = 2\text{ mA (CW)}$
$V_{2\text{k}\Omega} = IR = (2\text{ mA})(2\text{ k}\Omega) = 4\text{ V}$
$V_{4\text{k}\Omega} = IR = (2\text{ mA})(4\text{ k}\Omega) = 8\text{ V}$
$V_{6\text{k}\Omega} = IR = (2\text{ mA})(6\text{ k}\Omega) = 12\text{ V}$

a. $V_a = \mathbf{44\text{ V}}$, $V_b = 44\text{ V} - 4\text{ V} = \mathbf{40\text{ V}}$, $V_c = 44\text{ V} - 4\text{ V} - 8\text{ V} = \mathbf{32\text{ V}}$
$V_d = \mathbf{20\text{ V}}$

b. $V_{ab} = V_{2\text{k}\Omega} = \mathbf{4\text{ V}}$, $V_{cb} = -V_{4\text{k}\Omega} = \mathbf{-8\text{ V}}$
$V_{cd} = V_{6\text{k}\Omega} = \mathbf{12\text{ V}}$

c. $V_{ad} = V_a - V_d = 44\text{ V} - 20\text{ V} = \mathbf{24\text{ V}}$
$V_{ca} = V_c - V_a = 32\text{ V} - 44\text{ V} = \mathbf{-12\text{ V}}$

30. $V_0 = \mathbf{0\text{ V}}$, $V_{03} = \mathbf{0\text{ V}}$, $V_2 = (2\text{ mA})(3\text{ k}\Omega + 1\text{ k}\Omega) = (2\text{ mA})(4\text{ k}\Omega) = \mathbf{8\text{ V}}$
$V_{23} = \mathbf{8\text{ V}}$, $V_{12} = 20\text{ V} - 8\text{ V} = \mathbf{12\text{ V}}$, $\sum I_i = \sum I_o \Rightarrow I_i = 2\text{ mA} + 5\text{ mA} + 10\text{ mA} = \mathbf{17\text{ mA}}$

32. $V_L = \dfrac{3.3\ \Omega(12\text{ V})}{3.3\ \Omega + 0.05\ \Omega} = \mathbf{11.82\text{ V}}$
$I = \dfrac{12\text{ V}}{3.35\ \Omega} = 3.58\text{ A}$
$P = I^2R = (3.58\text{ A})^2\, 0.05\ \Omega = \mathbf{0.64\text{ W}}$

34. $VR\% = \dfrac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%$
$V_{FL} = IR = (2\text{ A})(28\ \Omega) = 56\text{ V}$
$VR\% = \dfrac{60\text{ V} - 56\text{ V}}{56\text{ V}} \times 100\% = 7.14\%$